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One-year results of maxillary overdentures supported by 2 titanium-zirconium implants - implant survival rates and radiographic outcomes

Zembic, Anja ; Tahmaseb, Ali ; Jung, Ronald E ; Wismeijer, Daniel

Abstract: **OBJECTIVE** To assess implant survival rates and peri-implant bone loss of 2 titanium-zirconium implants supporting maxillary overdentures at 1 year of loading. **MATERIAL AND METHODS** Twenty maxillary edentulous patients (5 women and 15 men) being dissatisfied with their complete dentures were included. In total, 40 diameter-reduced titanium-zirconium implants were placed in the anterior maxilla. Local guided bone regeneration (GBR) was allowed if the treatment did not compromise implant stability. Following 3 to 5 months of healing, implant-supported overdentures were inserted on two ball anchors. Implants and overdentures were assessed at 1, 2, 4, and 8 weeks after implant insertion and 2, 4, and 12 months after insertion of overdentures (baseline). Standardized radiographs were taken at implant loading and 1 year. Implant survival rates and bone loss were the primary outcomes. **RESULTS** Nineteen patients (1 dropout) with 38 implants were evaluated at a mean follow-up of 1.1 years (range 1.0-1.7 years). One implant failed resulting in an implant survival rate of 97.3%. There was a significant peri-implant bone loss of the implants at 1 year of function (mean, 0.7 mm, SD = 1.1 mm; median: 0.48 mm, IQR = 0.56 mm). **CONCLUSIONS** There was a high 1-year implant survival rate for edentulous patients receiving 2 maxillary implants and ball anchors as overdenture support. However, several implants exhibited an increased amount of bone loss of more than 2 mm. Overdentures supported by 2 maxillary implants should thus be used with caution as minimally invasive treatment for specific patients encountering problems with their upper dentures until more long-term data is available.

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1-year results of maxillary overdentures supported by 2 titanium-zirconium implants - implant survival rates and radiographic outcomes.

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Keywords: jaw, edentulous, maxilla, dental implants, survival rate, dental prosthesis, implant-supported, alveolar bone loss, bone resorption, titanium-zirconium, ball anchor

Running head: Maxillary overdentures on 2 implants

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Abstract

Objective: To assess implant survival rates and peri-implant bone loss of 2 titanium-zirconium implants supporting maxillary overdentures at 1 year of loading.

Material and Methods: Twenty maxillary edentulous patients (5 women, 15 men) being dissatisfied with their complete dentures were included. In total, 40 diameter-reduced titanium-zirconium implants were placed in the anterior maxilla. Local guided bone regeneration (GBR) was allowed if the treatment did not compromise implant stability. Following 3 to 5 months of healing, implant-supported overdentures were inserted on two ball anchors. Implants and overdentures were assessed at 1, 2, 4, 8 weeks after implant insertion and 2, 4 and 12 months after insertion of overdentures (baseline). Standardized radiographs were taken at implant loading and 1 year. Implant survival rates and bone loss were the primary outcomes.

Results: Nineteen patients (1 drop-out) with thirty-eight implants were evaluated at a mean follow-up of 1.1 years (range 1.0 – 1.7 years). One implant failed resulting in an implant survival rate of 97.3%. There was a significant peri-implant bone loss of the implants at 1 year of function (mean, 0.7 mm, SD = 1.1 mm; median: 0.48 mm, IQR = 0.56mm) .

Conclusions: There was a high 1-year implant survival rate for edentulous patients receiving 2 maxillary implants and ball anchors as overdenture support. However, several implants exhibited an increased amount of bone loss of more than 2mm. Overdentures supported by 2 maxillary implants should thus be used with caution as minimally invasive treatment for specific patients encountering problems with their upper dentures until more long-term data is available.

Introduction

In the past, complete dentures were the only treatment option for edentulous patients. Demographic trends indicate that the number of edentulous patients will be relatively high in future, thus the need for complete dentures might persist ([Carlsson & Omar 2010](#); [Polzer et al. 2010](#)).

Dental implants provided the edentulous patients with new treatment alternatives and several factors, such as patient satisfaction, denture retention, function and quality of life improved significantly ([Bouma et al. 1997](#); [Strassburger et al. 2006](#); [Wismeijer et al. 1997](#); [Zembic & Wismeijer 2013](#)).

Even though the frequency of placing oral implants is increasing, a previous review reported differing and small numbers (0.3%- 11%) of edentulous patients undergoing an implant treatment ([Zitzmann et al. 2007](#)). The most common reason for the patients not to choose for implants was found to be anxiety for surgical risks, followed by costs ([Ellis et al. 2011](#); [Walton & MacEntee 2005](#)).

Usually maxillary dentures show less retention problems than mandibular dentures. This is mainly caused by an enhanced vacuum effect through the anatomic shape of the maxilla. Once patients start to complain on their maxillary dentures, the retention is often compromised due to advanced ridge resorption. In these situations, bone augmentation techniques such as guided bone regeneration (GBR) or autogenous bone grafts are often inevitable when considering an implant treatment ([Chiapasco et al. 2009](#)). This in turn increases the risk for the patient, the patient's morbidity, the costs and the treatment time ([Sennerby & Roos 1998](#); [Stellingsma et al. 2004](#)). Hence, the aversion towards implants becomes evident.

One possibility to avoid bone-grafting procedures might be the use of narrow diameter implants in the anterior maxilla. Thereby, patient's risks and discomforts are reduced in situations with limited bone quantity. The survival of narrow diameter implants was found to be similar to regular diameter implants ([Sohrabi et al. 2012](#)). Despite respectable survival rates, it was advised to use narrow diameter titanium implants with caution due to risk of fracture in clinical use ([Allum et al. 2008](#); [Buser & von Arx 2000](#)).

A recently introduced diameter-reduced implant out of titanium and zirconium alloy offers superior mechanical strength compared to grade 4 titanium and might help overcome the risk of fracture ([Ho et al. 2008](#)). In addition, preclinical and clinical studies reported similar osseointegration of this implant to titanium implants ([Al-Nawas et al. 2012](#); [Barter et al. 2012](#); [Chiapasco et al. 2012](#); [Gottlow et al. 2012](#); [Thoma et al. 2011](#)).

A systematic review addressed the question of how many implants are ideal as overdenture support ([Roccuzzo et al. 2012](#)). The authors concluded that no answer could be given with regard to the maxilla on the basis of the current evidence. Former systematic reviews with the same goal advised to place at least 4 to even 6 implants in the maxilla ([Gallucci et al. 2009](#); [Klemetti 2008](#); [Sadowsky 2007](#); [Slot et al. 2010](#)). This relatively high number of implants as overdenture support makes the treatment both invasive and costly. More minimal-invasive treatment options should be offered to edentulous patients with denture problems out of the above-mentioned reasons. It remains unclear however, how many implants can be minimally inserted in the edentulous maxilla as overdenture support ([Jemt et al. 1996](#); [Klemetti 2008](#); [Kronstrom et al. 2006](#); [Roccuzzo et al. 2012](#)).

The placement of 2 implants in the maxilla, as support for overdentures was a treatment option that did not prevail in the past due to low implant survival rates and pronounced bone loss ([Bergendal & Engquist 1998](#); [Quirynen et al. 1991](#); [Sanna et al. 2009](#)). The implants used in these studies had a machined surface. The implant surface is crucial for implant osseointegration. Hence, rough surface implants replaced machined surface implants due to their superior effect on bone integration ([Han et al. 1998](#); [Ivanoff et al. 2001](#); [Rasmusson et al. 2001](#); [Wennerberg & Albrektsson 2009](#)). Consequently, the survival rates significantly increased for rough surface implants placed in the edentulous maxilla compared to machined surface implants at 1, 3, 5 and 10 years ([Lambert et al. 2009](#)).

The new titanium-zirconium implant exhibits the successful highly hydrophilic, sandblasted, large-grit, acid-etched surface. Based on the encouraging clinical results, this implant might allow new treatment possibilities, such as the formerly un-established but minimal-invasive treatment with 2 implants to support maxillary overdentures ([Mericske-Stern et al. 2000](#)).

The aim of the present prospective clinical study was to assess survival rates and peri-implant bone loss of 2 titanium-zirconium implants supporting maxillary overdentures at 1 year of loading.

Material and Methods

Patients and study procedure

The present study was designed as a prospective clinical cohort study including 20 edentulous patients experiencing problems with their maxillary complete dentures. These patients were part of a previously published study describing the details of the procedures ([Zembic & Wismeijer 2013](#)).

In brief: the study was approved by the local ethical committee (Medisch Ethische Toetsingscommissie van Vrije Universiteit Medisch Centrum). The treatment was performed at the Academic Center for Dentistry Amsterdam (ACTA), the Netherlands. All patients were treated by one clinician.

Implant planning

Upon adjusting the existing dentures or fabricating new ones, a cone beam computed tomography (CBCT)-scan (NewTom 5G, QR, Verona, Italy) was performed using a scan template (duplicate of the denture with barium sulfate). Implants were planned in the prosthetic canine position preferably (coDiagnostiX, Dental Wings Inc. Montreal, Canada). In case of major insufficiency of bone quantity in this region (primary bone graft inevitable), implants were planned posterior or anterior to the canine. In case of minor insufficiency of bone quantity (dehiscence or fenestration defects) not compromising implant stability, implants were planned in canine area. The automatic parallelization feature of the planning software was used to ensure the most parallel position of the 2 implants in the mesio-distal as well as bucco-lingual plane. When needed, the parallelized implant position was adjusted manually according to the individual bone conditions. The scan template was translated into a template for guided surgery according to the virtual implant planning and using the manufacturer's device (gonyX™, Institut Straumann AG, Basel, Switzerland).

Surgery

The patients received antibiotics as single shot dose 1 hour preoperative (Amoxicilline 3g) (Amoxicillin Sandoz® Pharmaceuticals AG, Rotkreuz, Switzerland). Mouth rinsing was administered 1 day before surgery with a solution of 0.12% chlorhexidine digluconate (Perio•Aid®, Dentaïd, Barcelona, Spain).

In situations with no bone defects according to the virtual planning, soft tissue punches were performed through the sleeves by means of disposable biopsy tissue punches with a standardized diameter of 4mm (Integra™ Miltex®, Plainsboro, New Jersey, USA). Subsequently, guided drilling was performed (Straumann Guided® Surgery kit, Institut Straumann AG, Basel, Switzerland). Two diameter-reduced implants (Roxolid® Tissue Level, 3.3mm diameter, Regular Neck, Institut Straumann AG, Basel, Switzerland) were placed through the guided implant mount. Implants with a standard shoulder height of 2.8mm or with a reduced shoulder height of 1.8mm were placed, dependent on the mucosa thickness. The rough-smooth border of the implants was placed either at bone crest or slightly subcrestal by means of a guided vertical reference. Closure screws or healing abutments were inserted dependent on the mucosa thickness and the implants were exposed to transmucosal healing for 2 months.

In situations with expected bone defects, a flap was raised and guided bone regeneration (GBR) was applied simultaneously with the placement of two diameter-reduced implants. Implants were placed in the same way as mentioned above. Autogenous bone chips gained from the surrounding bone were applied on the exposed implant threads, followed by a xenograft material (Bio-Oss®, Geistlich Pharma AG, Wolhusen, Switzerland). A resorbable collagen membrane was used to cover the graft (Bio-Gide®, Geistlich Pharma AG, Wolhusen, Switzerland). Closure screws were inserted into the implants. A periosteal releasing incision was performed if needed and the flap was closed tension-free with non-resorbable PTFE monofilament sutures (Cytoplast™, Osteogenics Biomedical, Inc., Lubbock, USA). Submucosal implant healing was allowed for 4 months.

The patients were instructed postoperatively to rinse twice daily for 2 weeks with a solution of 0.12% chlorhexidine digluconate (Perio•Aid®, Dentaïd, Barcelona, Spain). Analgesics (Brufen® Brufen 600 mg, Abbott, Illinois, USA) were prescribed according to patient's individual requirements. All patients were instructed not to wear the maxillary dentures for 1 week after implant surgery. One week post-operatively, sutures were removed and the dentures were thoroughly grinded out in the implant area. Soft relining was done occasionally (Soft-Liner, GC corporation, Tokyo, Japan). If the implant healing was submerged, abutment connection was performed after 4 months and healing abutments were inserted. One week thereafter, implant impressions were made. In case of transmucosal healing, implant impressions were

performed 2 months after implant insertion. Radiographs of the implants were performed using the long-cone parallel technique for control of the correct fit of the impression posts ([Updegrave 1951](#)).

Prosthodontic procedure

Definitive overdentures were inserted 3 and 5 months after implant placement. Thus, all implants were loaded conventionally ([Esposito et al. 2007](#)).

At the day of overdenture insertion, 2 titanium retentive anchors with a standardized height of 3.4 mm (Retentive anchor abutment, Institut Straumann AG) were screwed into the implants with a defined torque of 35 Ncm. The corresponding matrices (Titanium matrix for retentive anchor, Institut Straumann AG, Switzerland) were incorporated into the overdentures by the dental technician. The overdentures were designed with a metal framework and conventional full palatal coverage. The patients wore these overdentures for 2 months. Subsequently, the overdentures were sent to the lab for reduction of the palatal coverage and the patients wore the modified overdentures for another 2 months. This overdenture modification was part of another research project ([Zembic et al. 2013](#)). The patients could thereafter choose which overdenture type they preferred, either with closed or open palatal design. The occlusion of the overdentures was controlled and corrected to be balanced and without anterior contacts ([Horn 1987](#)). Specific instructions were given on overdenture handling and oral hygiene. The patients were enrolled in an individual dental hygiene program every 6–12 months, either at the University of Amsterdam or at private practices.

Clinical evaluation and outcome measures

The patients were followed-up 1, 2, 4, 8 weeks after implant insertion and 2, 4 and 12 months after insertion of overdentures (baseline). At all visits, a clinical control of mucosa, implants and overdentures took place and adverse events were noted. Radiographic assessments were performed at implant loading and 1 year of follow-up.

The main outcome measures were:

- Implant survival rate
- Peri-implant marginal bone loss

Secondary outcomes were:

- Peri-implant mucosa
- Overdentures

An implant was considered as “surviving implant”, if it remained inserted during the observation period ([Albrektsson et al. 1986](#)).

Standardized digital radiographs were performed perpendicular to the implant axis with the long-cone technique ([Updegrave 1951](#)). For this purpose, lab-made individual implant-supported x-ray holders were used which were made on the cast after implant impression (Figure 1). Two examiners (BH, AZ) evaluated mesial and distal bone levels at implant loading and 1 year using a software program (Image J; National Institutes of Health, Bethesda, MD, USA). The distance from the first bone-to-implant-contact to the implant shoulder as reference point was measured in 0.1 mm increments (Figure 2a,b). The known distance between implant threads was used for calibration (1.25 mm). In case of measurement discrepancies of more than 0.5 mm, the radiographs were re-examined and discussed until a consensus was found. The Cohen’s Kappa- coefficient was calculated to assess the agreement between the two examiners. Mesial and distal bone loss measurements were averaged per implant. Then, the average of both implants per patient was used for the analysis of bone loss between baseline and 1 year, **i.e. the unit of the analysis was the patient.**

Statistical Analysis

Descriptive statistics was applied calculating means, medians, standard deviations and interquartile ranges of bone loss. Bone loss from baseline to 12 months was **statistically** assessed using **the Wilcoxon signed rank test**. The level of significance was set at 5%.

Results

Patients and implants

In total, forty implants in twenty maxillary edentulous patients (5 women, 15 men) were included in the present study. The mean age of the patients was 61 years (range 45-84 years) at the time of surgery.

Six patients (6 men) were smokers, whereas 14 patients (5 women, 9 men) were non-smokers. One patient (smoker) withdrew from the study due to personal reasons. Consequently, thirty-eight titanium-zirconium implants in nineteen patients were examined at a mean follow-up of 1.1 years (range 1.0 – 1.7 years).

Primary implant stability was achieved with all implants.

The location and distribution of implant type and length is illustrated in Table 1.

The majority of implants (n=34) were placed in pristine bone with a flapless approach. An open flap procedure and simultaneous minor bone augmentation was performed for 4 implants.

Fifteen patients preferred an overdenture with reduced palatal coverage, whereas four patients chose for a full palatal coverage.

In the opposing jaw, fifteen patients had mandibular implant-supported overdentures, 3 patients had complete mandibular dentures and 1 patient had three remaining natural teeth and a partial denture.

Implant survival

The implant survival rate at 1 year amounted to 97.3%.

One implant failed out of the evaluated thirty-eight implants due to loss of osseointegration 2 weeks prior to the 1-year follow-up visit. This implant was placed flapless without GBR. The patient was occasional pipe smoker and chose for an overdenture with reduced palatal coverage. There was abnormal tooth wear visible 7 months following overdenture insertion indicating parafunctions.

In the lower jaw the patient was wearing an overdenture on 2 implants and a bar. The patient reported pain when removing the overdenture and was scheduled for a control. The implant was mobile and could be removed manually. The socket was cleaned carefully and all granulation tissue was removed. A new implant was successfully re-inserted at the same location (region 23) after 2 months of healing with minor local GBR.

Marginal bone loss

The inter-rater agreement (Kappa) of the two examiners was $\kappa = 0.82$, which corresponds to a very good agreement.

The bone loss is illustrated in Tables 2-5 and Figures 3 a-d, 4 a-d.

There was significant bone loss at 1 year ($p < 0.01$, 95% CI: 0.28 – 0.95 mm, Wilcoxon signed rank test). Overall, when averaging over implants and patients, the mean bone loss amounted to 0.7 mm (± 1.1) and the median bone loss was 0.48 mm (IQR: 0.56 mm).

At the 12-month follow-up, bone loss up till 2 mm was observed around twenty-three implants (62%). Bone loss of 2–3 mm was found around 1 implant (3%), whereas bone loss of more than 3 mm was identified around 2 implants (5%). In eleven implants (30%) either no bone loss or slight bone gain was evident.

The descriptive bone loss of implants split to the variables GBR, smoking and overdentures with/without palatal coverage is presented in Tables 3-5.

Peri-implant mucosa

Until 2 months of loading:

- Mucosa overgrowth around 7 implants of 5 patients
- Pain spot in 1 patient

At 2 months of loading:

- Mucosa overgrowth around 3 implants of 2 patients

At 4 months of loading:

- No events

At 1 year of loading:

- Mucosa overgrowth around 1 implant of 1 patient
- Recession around 1 implant of 1 patient

In all patients with mucosa overgrowth mucosa excisions were performed. In total, 13 soft tissue events occurred at 1 year. Two clinical case examples are presented in Figure 5a,b.

Overdentures

Until 2 months of loading:

- 1 overdenture tooth 23 fracture (lab repair)
- 1 rebasing (direct)

At 2 months of loading:

- 1 fracture of the buccal shield in region of 11-14 (lab repair)
- 1 rebasing (direct)
- 1 phonetic problem, palatal coverage thinned out and directly rebased
- 1 patient reports pain when inserting the overdenture in the morning (this patient suffered from mucosa overgrowth)

At 4 months of loading:

- 1 patient reports pain when inserting the overdenture in the morning (same patient as at 2 months)

Between 4 months and 1 year:

- 2 partial overdenture tooth fractures (teeth 11, 12) in 2 patients (direct repair)
- 1 partial direct rebasing
- 1 direct rebasing, 1 indirect rebasing in one and the same patient
- pronounced tooth abrasion and fractured incisors in 1 patient (no repair needed, just polished; this patient lost 1 implant)

At 1 year of loading:

- 1 minor overdenture tooth fracture 22 (no repair needed, just polished)

Overall, there were 4 minor fractures which could be resolved chairside by either polishing or composite build-ups and 2 major fractures, which were sent to the dental technician for repair. At 1 year, 5 overdentures were rebased directly chairside. One overdenture was sent to the lab for an indirect rebasing.

Discussion

The results of the present study demonstrated a high implant survival rate for 2 maxillary implants supporting overdentures at 1 year of function. There was significant peri-implant bone loss from implant loading to the 1-year follow-up.

Implant survival rate

A lower implant survival rate (82.1 %) than in the present study was reported in a study on 2 narrow diameter implants placed in the canine area of fourteen patients ([Weng & Richter 2007](#)). The mean observation period was 25.6 months which is longer than in the present study. Likewise as in the present study, implants were loaded with a conventional approach, i.e. 2 and more months following implant placement ([Esposito et al. 2007](#)). Conventional implant loading in the edentulous jaw supporting overdentures had a positive impact on implant survival with less implant failures compared to shorter healing times ([Kern et al. 2016](#); [Schimmel et al. 2014](#)). Still, there was a high number of failures in the named study even after 7 months of healing before loading.

The overdentures were of similar design as in the present study with a metal framework and open palatal design but supported by 2 telescopic abutments ([Weng & Richter 2007](#)). Telescopic abutments are more rigid than ball anchors which might have affected the load transfer to implants and accordingly the implant survival rates in a negative way. On the other hand, there were no differences for the survival rates of 4 maxillary implants supporting overdentures with either telescopic crowns, bar or locator attachments in a prospective study at 3 years ([Zou et al. 2013](#)). Unfortunately, there was no random allocation of the 3 attachment systems. One might speculate that the attachment system is not likely to influence implant survival rates when 4 implants are placed in the maxilla, but might have an effect when less than 4 implants are inserted. Furthermore, this might apply primarily for rigid telescopic attachments compared to ball attachments with a higher degree of freedom. In another study, the patients were randomly assigned to splinted maxillary implants by means of a bar and to un-splinted implants by means of ball attachments ([Bergendal & Engquist 1998](#)). Sixteen patients received less than 4 implants in the maxilla. No significant differences were found for the survival of splinted vs. un-splinted implants at 5 years ([Bergendal & Engquist 1998](#)). Thus, bar and ball

attachments seem not to have an impact on implant survival rates, even when less than 4 implants are placed in the maxilla.

Another study also presented an inferior 1-year survival rate of 84.6% for 3 narrow diameter implants supporting maxillary overdentures ([Payne et al. 2004](#)). In contrast to the present study, all implants were placed in combination with ridge-expansion and ridge-splitting, a technique not well approved with regard to implant survival rates. On the other hand, only minor GBR was applied in the 4/38 study implants for coverage of dehiscence or fenestration defects. The GBR technique is well documented in implant dentistry. A systematic review reports high survival rates of 95.7% (range 84.7% to 100%) at 1-10 years for implants placed with GBR to treat peri-implant dehiscence and fenestration defects in the maxilla ([Chiapasco & Zaniboni 2009](#)). Thus, it is unlikely that the applied minor GBR had an influence on the survival rate in the present study. It does not surprise hence that the failed implant was not in conjunction with GBR.

The favorable implant survival rates in the present study should be interpreted with caution though due to the short observation period. The implants are to be monitored over a longer period before this treatment option can be recommended on a large scale. Besides, less than 4 maxillary implants as overdenture support showed a 3 times increased estimated risk for implant loss compared to 4 maxillary implants (2.3 vs. 7.2, $p < 0.0001$) according to a recent systematic review ([Kern et al. 2016](#)).

On the other hand it is well known that most implant failures are early failures and occur during initial implant healing, whereas less than 50% of the failures usually correspond to late failures, which happen when the established osseointegration cannot be sustained ([Schley & Wolfart 2011](#)).

Peri-implant bone loss

The majority of implants (62%) in the present study showed a maximum bone loss of 2 mm, which is within the range of previously reported implant success criteria ([Albrektsson et al. 1986](#)). Three implants in 2 patients (8% of the implants) lost more than 2mm of bone. Several reasons might have contributed to this finding. These implants were placed flapless without GBR. Still, 1 of these 2 patients had poor initial bone conditions. Bone quality and quantity are often compromised in the maxilla ([Chan et al. 1998](#)). Both patients had overdentures with reduced palatal coverage, which might have subjected the implants to biomechanical stress ([Rodriguez et al.](#)

[2000](#)). The other patient had good initial bone conditions but was smoking 1-package cigarettes per day. Smoking is well known to have a harmful effect and cause more peri-implant bone loss in the maxilla ([Clementini et al. 2014](#); [Vervaeke et al. 2013](#)). A current systematic review found smoking to increase the annual rate of bone loss by 0.16 mm/year ([Clementini et al. 2014](#)). Furthermore, this patient showed abnormal tooth wear at 7 months indicating parafunctions.

The same implant type and material was used for rehabilitation of the atrophic maxilla in a retrospective study ([Cordaro et al. 2013](#)). Ten patients received 4 implants and locator abutments as overdenture support. There was less mean bone loss (0.55 ± 0.5 mm) at a mean observation period of 13.5 months than reported in the present study. Retrospective studies tend to be less critical than prospective ones and often show more favorable outcomes. In addition, the attachment system might have contributed to minor bone loss. An advantage of locator abutments as against to ball anchors with pre-defined height is the wide range of available locator heights. This enables an optimal choice of the retentive anchor according to the individual mucosa thickness. Thereby, the peri-implant soft tissue support is facilitated and mucosal problems can be prevented. Thirty percent of the implants showed mucosa overgrowth in the present study, inducing a peri-implant mucositis. This might explain the bone loss. The use of e.g. locators might have been more advantageous, but due to no available evidence on locators in the edentulous maxilla by the time of study beginning, it was chosen to use the well proven ball anchors.

Interestingly, some bone loss is evident on the baseline x-rays, i.e. from implant insertion to implant loading. A similar observation with a mean bone loss of 1.35 ± 0.1 mm was found between implant surgery and 12 weeks in a prospective study on 3 maxillary implants supporting overdentures ([Ma et al. 2015](#)). In the edentulous upper jaw positioning of the x-ray is difficult to achieve in a reproducible angle due to the palatal anatomy. To be able to compare bone levels in a standardized way, individual stents were fabricated on the casts after implant impression. Thus, baseline radiographs were taken at prosthesis insertion in the present study, i.e. implant loading, which is in agreement with the consensus of the Sixth European Workshop on Periodontology (2008) ([Heitz-Mayfield 2008](#)). Considering the questionable benefit of baseline x-rays at the day of implant insertion, it nevertheless would have been interesting to see how much bone was lost during the healing period.

The healing pattern of most implants (88%) was transmucosal. Several studies found no significant difference in bone loss when transmucosal implant healing was compared to submerged implant healing ([Astrand et al. 2002](#); [Cecchinato et al. 2004](#); [Ericsson et al. 1997](#); [Hammerle et al. 2012](#)). Those studies base on partially edentulous patients. Transmucosal healing in the edentulous jaw might in turn expose implants to risks such as premature loading through the denture and mucosa overgrowth.

Taking into account the growing elderly population, there is a need of clinical trials to validate the use of freestanding implants supporting maxillary overdentures ([Gallucci et al. 2009](#)). Thereby, priority should be given to straightforward, efficient and minimal invasive treatment procedures that come along with less surgical risks for the patients ([Chiapasco et al. 2009](#)). This might be achieved by the placement of less than 4 implants in the maxilla as overdentures support. To substantiate the treatment concept of only 2 maxillary implants, the present results have to be monitored over a longer period of time and corroborated by more clinical data.

Conclusions

The high short-term implant survival rates suggest that maxillary overdentures supported by 2 implants might be a minimal invasive treatment alternative worth to be considered in specific patients encountering problems with conventional maxillary dentures. The increased bone loss has to be considered though and might have a negative effect on the clinical long-term outcome of this treatment option. Thus, monitoring over a longer period than 1 year and more clinical studies are needed to prove this treatment option to be successful.

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Figure 1. Individualized lab-made radiographic holder attached to the ball anchor.

Figure 2a. The distance from the first bone-to-implant-contact to the implant shoulder as reference (yellow line) was measured.

Figure 2b. Standardized radiograph illustrating the measured distance from bone level to implant shoulder as reference (yellow arrows).

Figures 3-4. Two clinical cases illustrating the considerable variations of bone loss from baseline (implant loading) to the 1-year follow-up).

Figure 3a.
Bone level of implant 13 at baseline (implant loading)

Figure 3b.
Bone level of implant 13 at 1year of loading

Figure 3c.
Bone level of implant 23 at baseline (implant loading)

Figure 3d.
Bone level of implant 23 at 1year of loading

Figure 4a.
Bone level of implant 13 at baseline (implant loading)

Figure 4b.
Bone level of implant 13 at 1year of loading

Figure 4c.
Bone level of implant 23 at baseline (implant loading)

Figure 4d.
Bone level of implant 23 at 1year of loading

Figure 5. Mean peri-implant bone loss (mm) from baseline to 1 year per implant (n=37). One implant was lost. Negative values represent bone gain (mm).

Figure 6a: 1-year follow-up of 2 maxillary ball anchors surrounded by healthy mucosa.

Figure 6b: Mucosa overgrowth around ball anchors at the 1-year follow-up.

Table 1. Distribution of implants (n) according to type (Standard Plus/Standard), length and region.

	Implant type			Implant length				Implant region						
	SP	S	Total	8mm	10mm	12mm	Total	12	13	14	22	23	24	Total
Implants (n=38)	15	23	38	1	12	25	38	1	16	2	4	14	1	38

Table 2. Peri-implant bone loss (mm) at 12 months (mean, standard deviation, median, interquartile range, range). One implant was lost until 12 months (n=37).

Bone loss at 12 months	n	Mean (mm)	SD (mm)	Median (mm)	IQR (mm)	Range (mm)
	37	0.7	1.1	0.48	0.56	-2.4 - 5.8

Table 3. Bone loss (mm) at 12 months split for implants with and without GBR (mean, standard deviation, median, range).

Bone loss at 12 months	n	Mean (mm)	SD(mm)	Median (mm)	Range (mm)
Implants with GBR	4	0.9	0.7	0.8	0.1 to 1.8
Implants without GBR	33	0.7	1.1	0.4	-0.7 to 2.8

Table 4. Bone loss (mm) at 12 months split for patients being smokers and non-smokers (mean, standard deviation, median, range).

Bone loss at 12 months	n	Mean (mm)	SD(mm)	Median (mm)	Range (mm)
Implants smokers	6	1	1.6	0.4	0.1 to 4.2
Implants non-smokers	13	0.5	0.8	0.5	-0.7 to 2.8

Table 5. Bone loss (mm) at 12 months for implants supporting overdentures with and without palatal coverage (mean, standard deviation, median, range).

Bone loss at 12 months	n	Mean (mm)	SD(mm)	Median (mm)	Range (mm)
Overdentures with palatal coverage	4	0.1	0.6	0.3	-0.7 to 0.7
Overdentures without palatal coverage	15	0.9	1.2	0.5	-0.1 to 4.2

Figure 1



Figure 2a

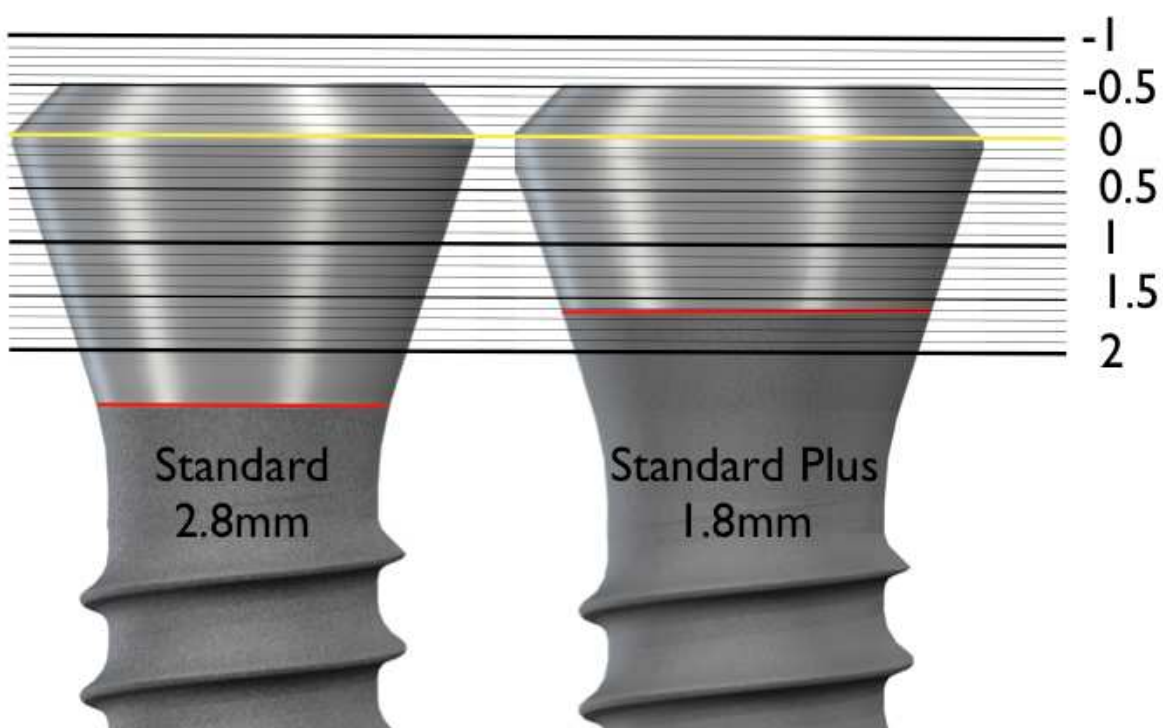


Figure 2b

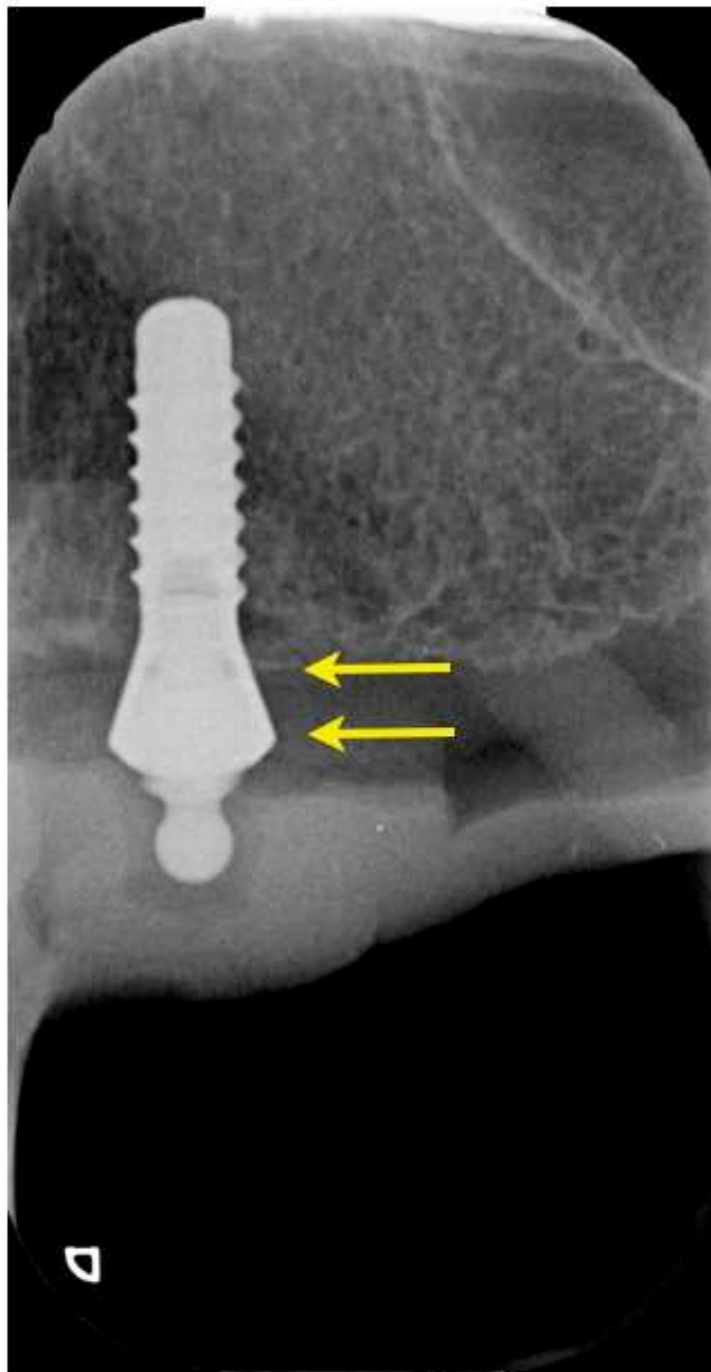


Figure 3a



Figure 3b



Figure 3c

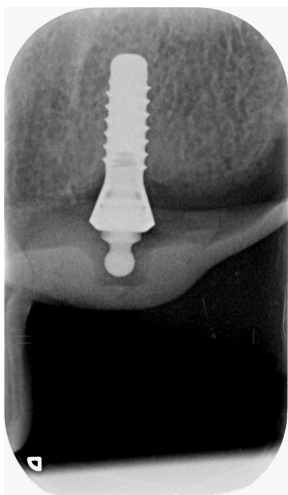


Figure 3d

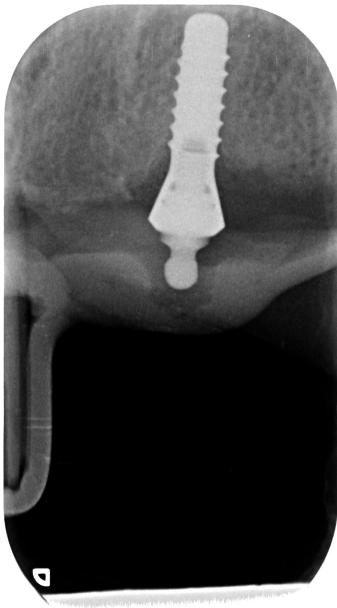


Figure 4a

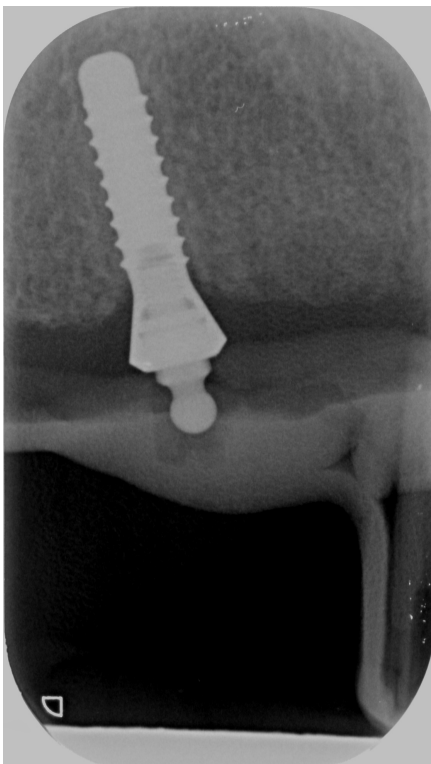


Figure 4b



Figure 4c



Figure 4d



Figure 5

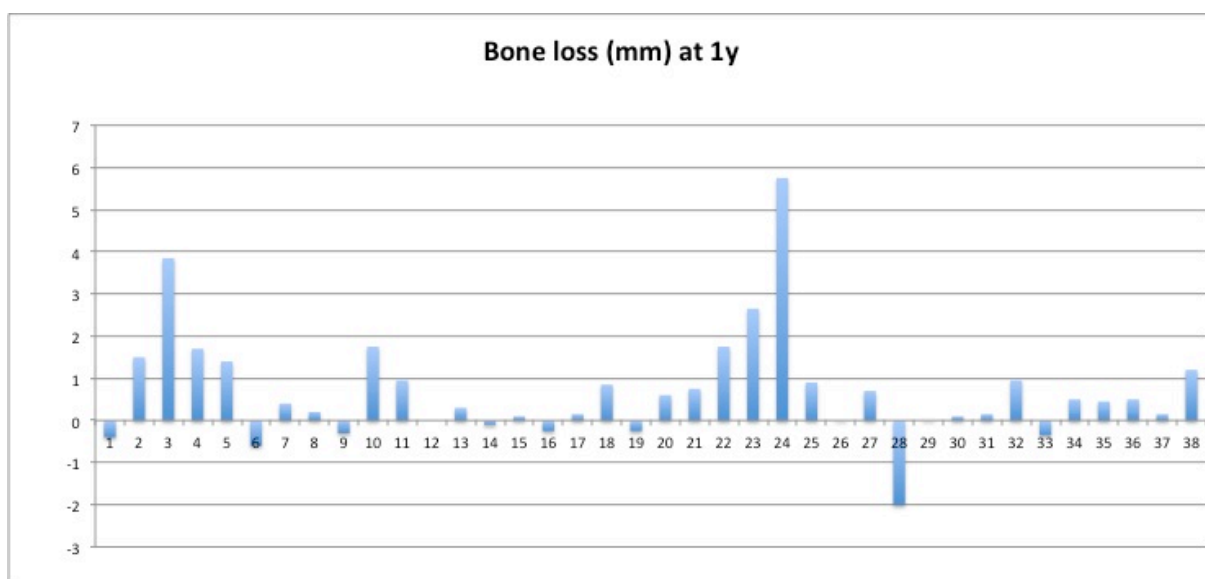


Figure 6a



Figure 6b

